

# Design and Testing of a Cellular Composite Active Twist Wing

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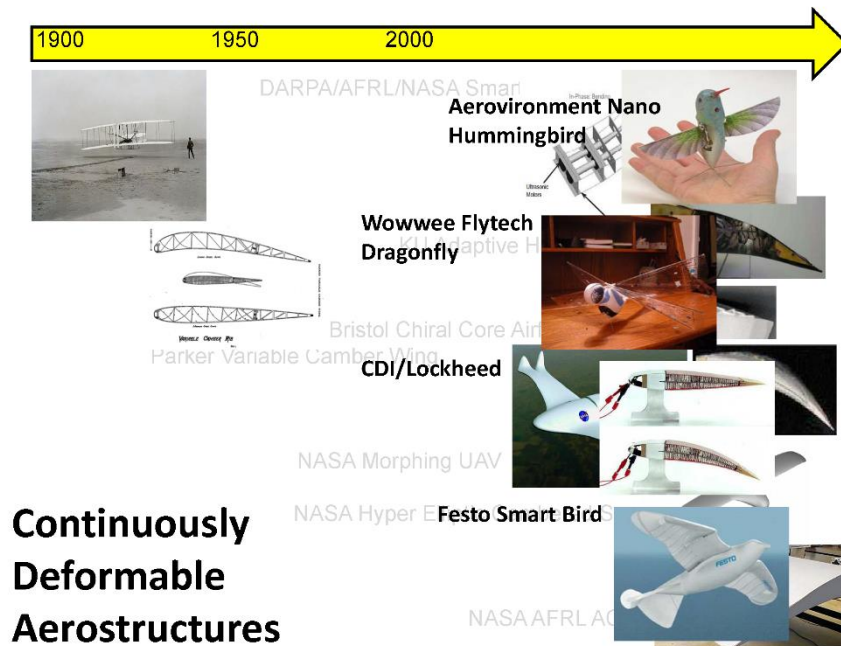
<sup>~</sup>Massachusetts Institute of Technology

<sup>\*</sup>NASA Ames Research Center

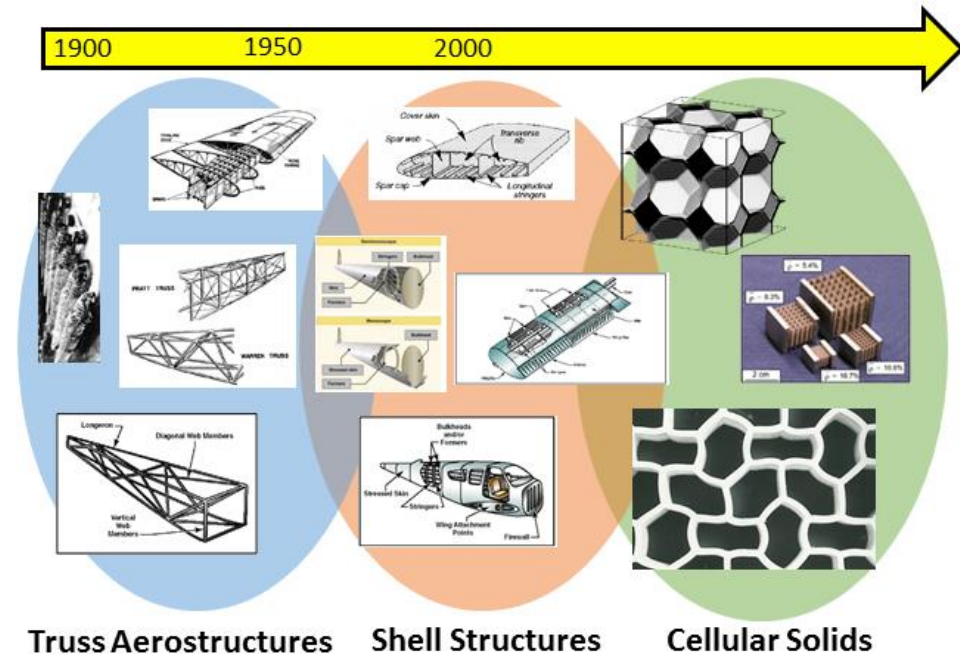
# Motivation

# Morphing Wings and Lattice Structures

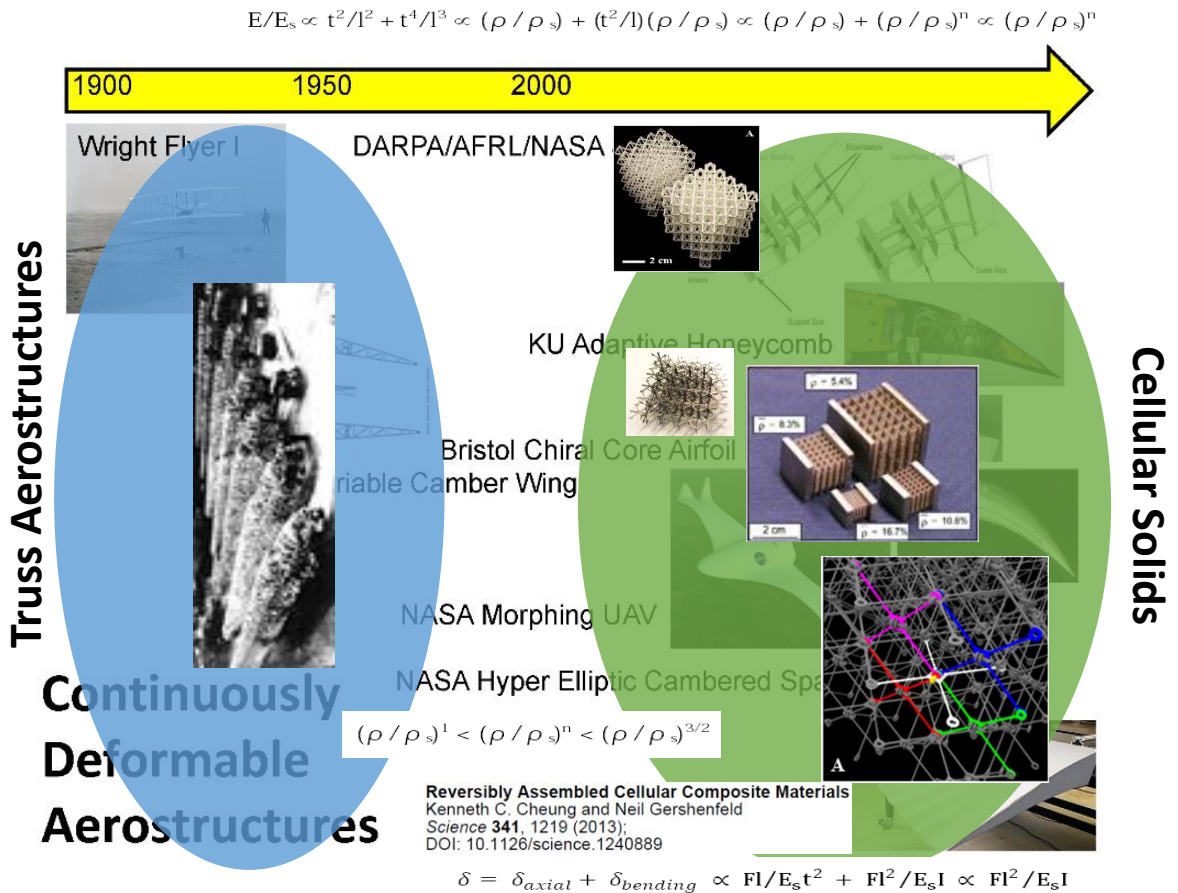
## Aerodynamic Efficiency



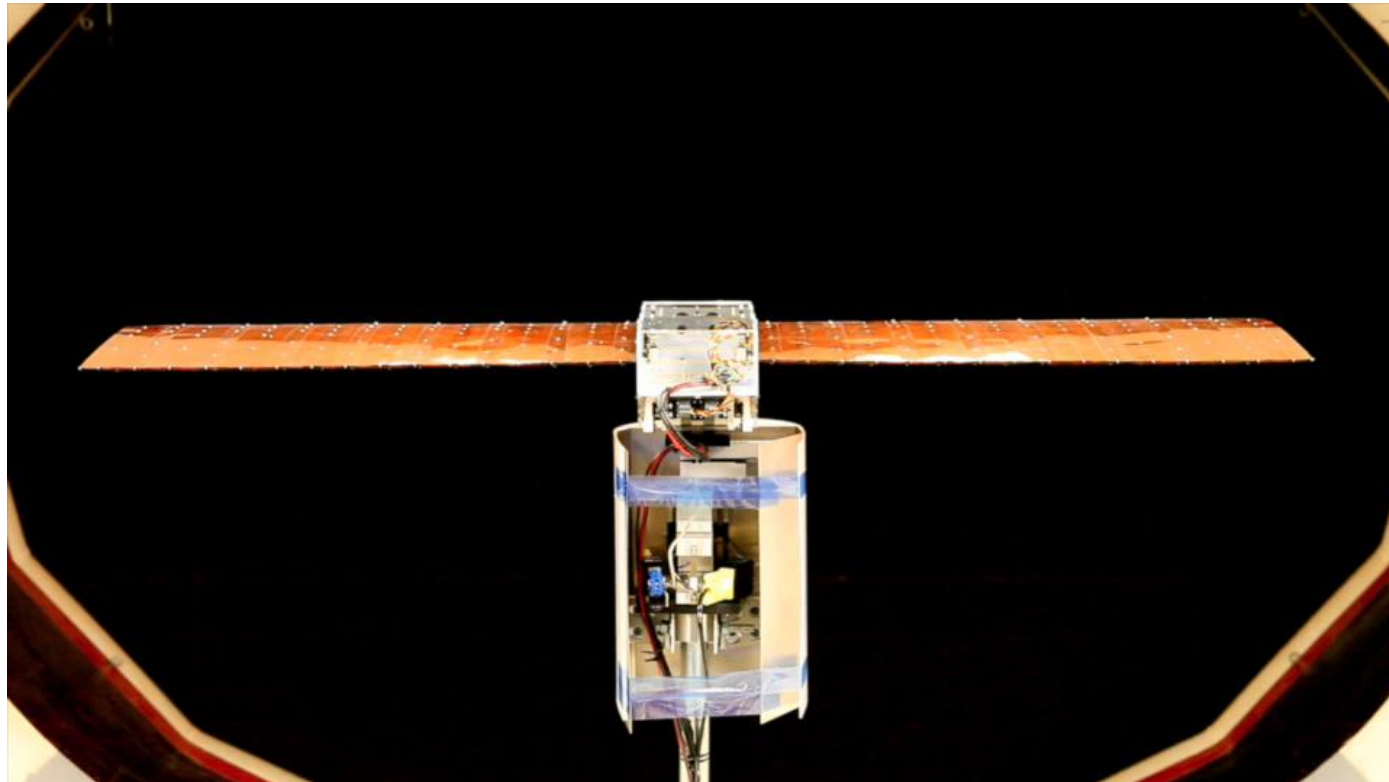
## Structural Efficiency



# Combining to Create Morphing Lattice Wings

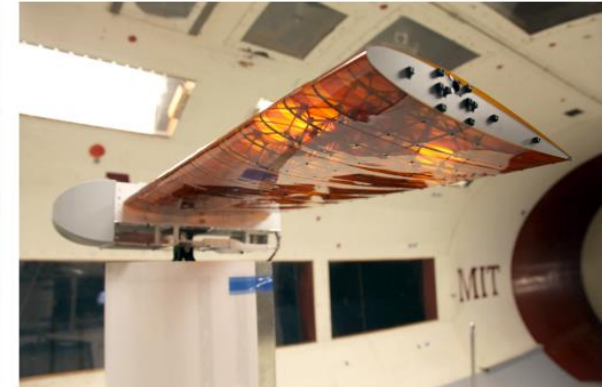
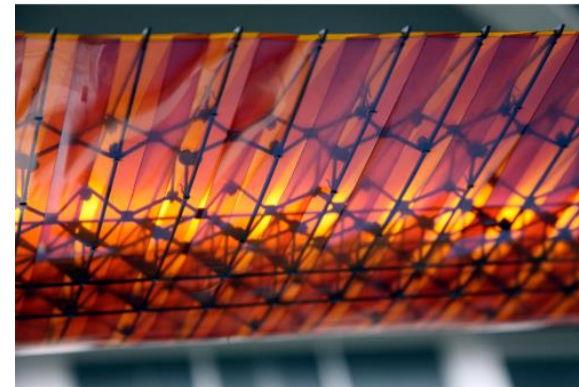
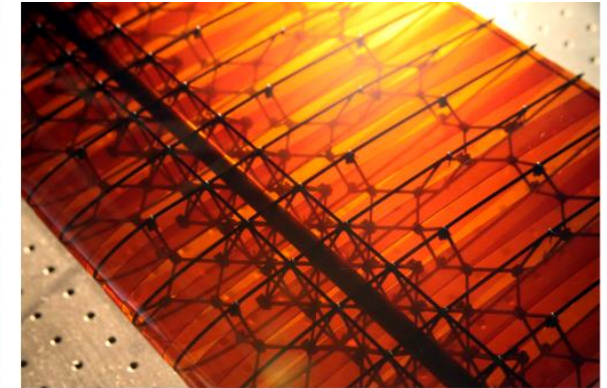
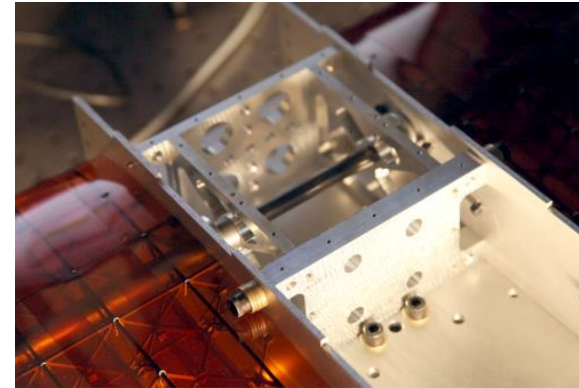
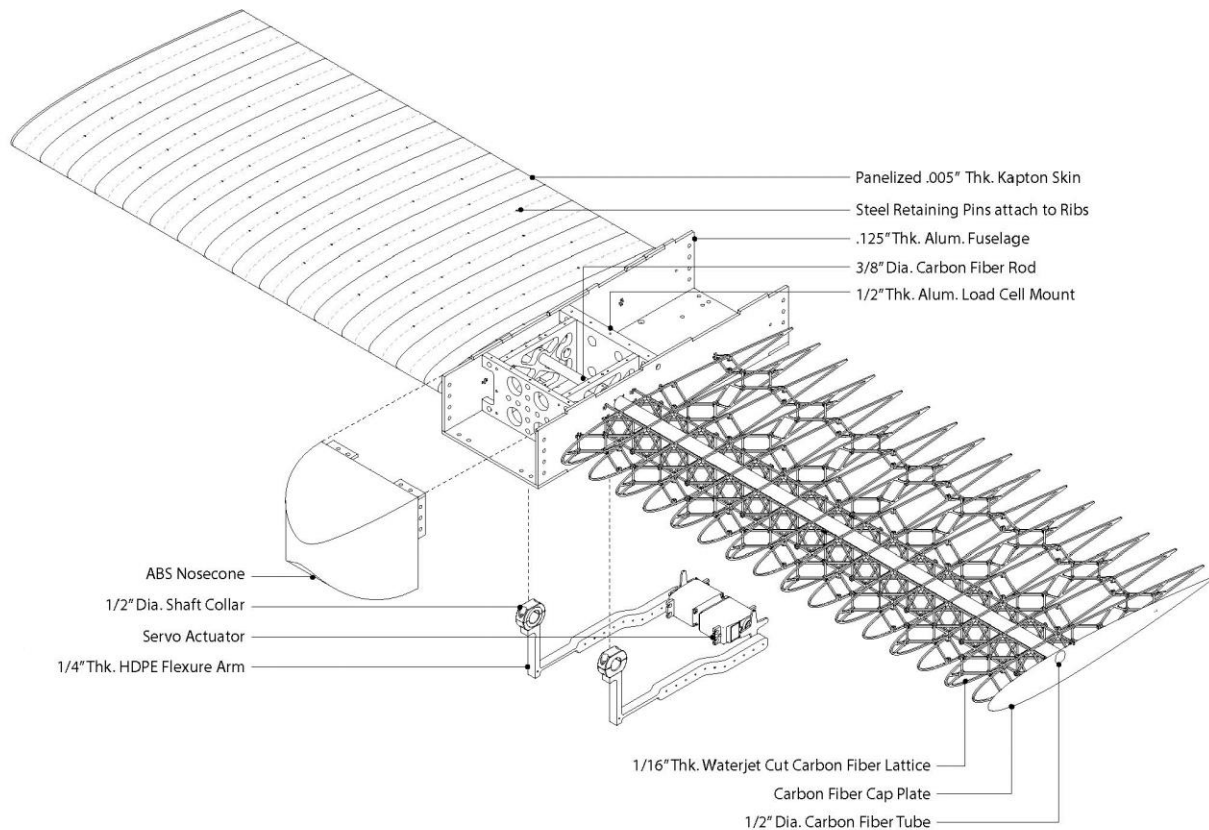


# Active Twist Capabilities





# Structural Design



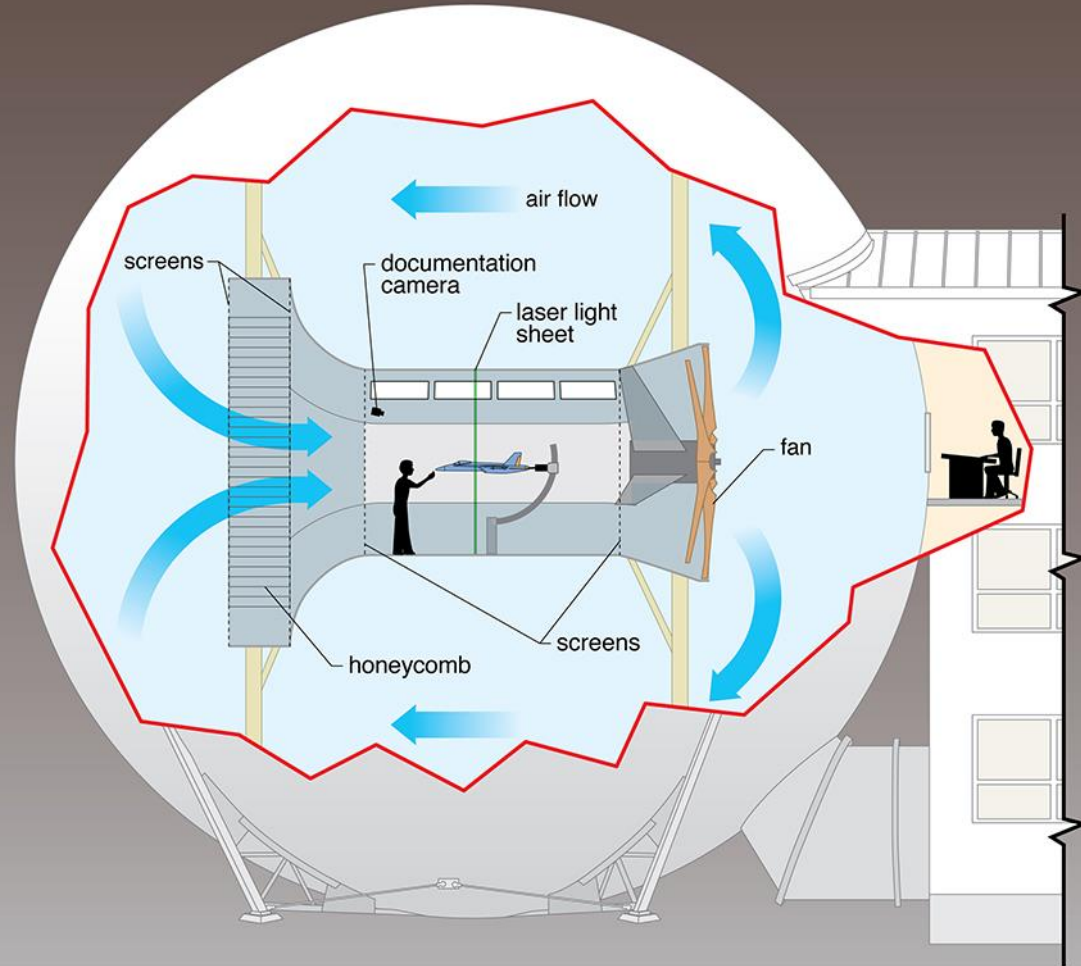
# Testing Approach

# 12-Foot Low Speed Tunnel



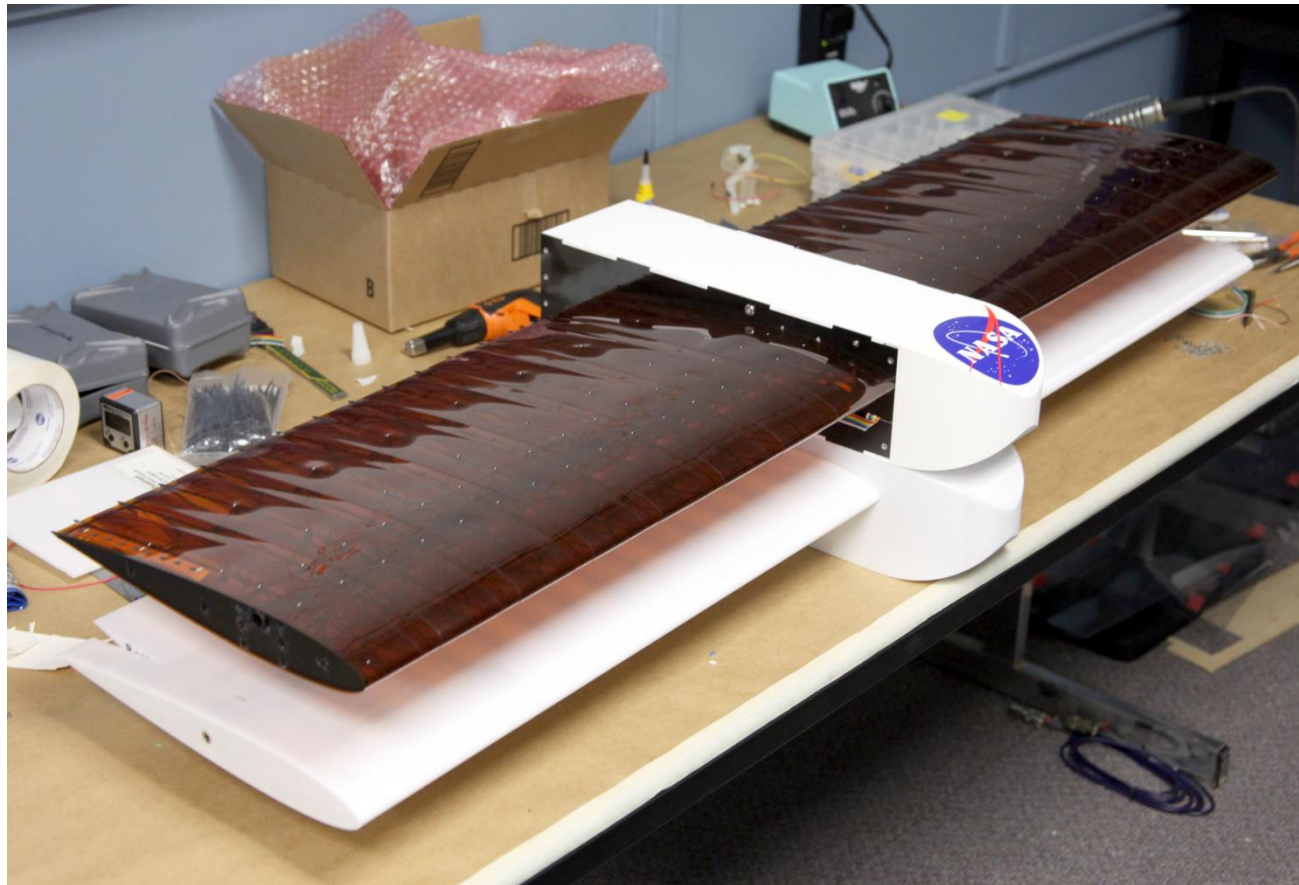
## Specifications

- Type: Atmospheric, closed throat, annular return
- Test section: 8 sided, 12 feet wide, 15 feet long
- Operational: 1939 (as free-flight tunnel)
- Motor: 280 hp
- Velocity: 0 - 77 ft/s
- Static force and moment: -10 to 90 degrees alpha, +/- 90 degrees beta
- Surface pressures
- Arbitrary motion forced oscillation
- Free-to-roll
- Flow visualization (laser light sheet, tufts, smoke, sublimating chemicals)





# Compare Geometrically Identical Rigid and Flexible Models



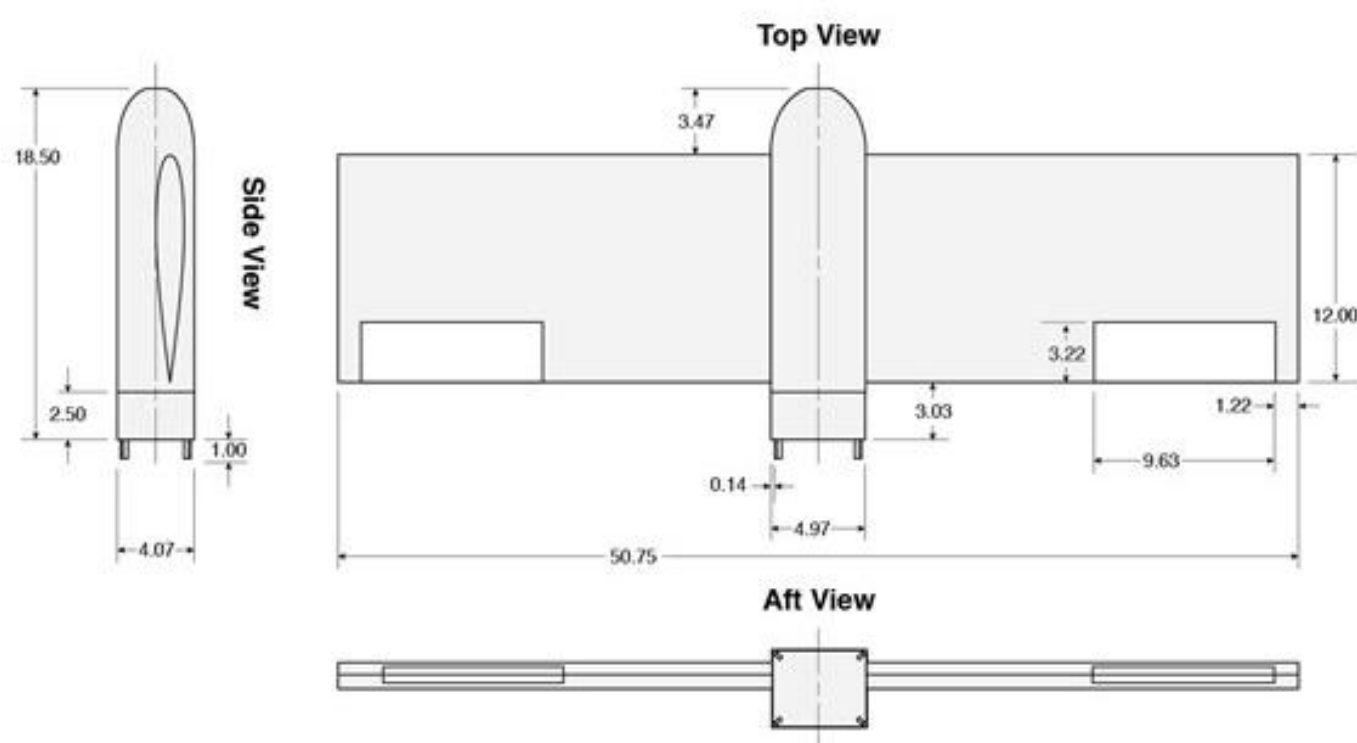
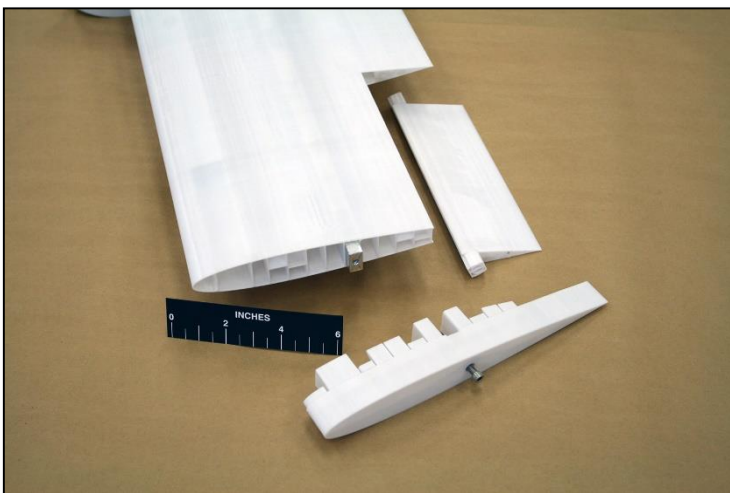
# Rigid Model has Flaps to Compare to Wing Twist

**Flexible twist**  
Cont. variable

-6° T.E. up to  
+10° T.E. down

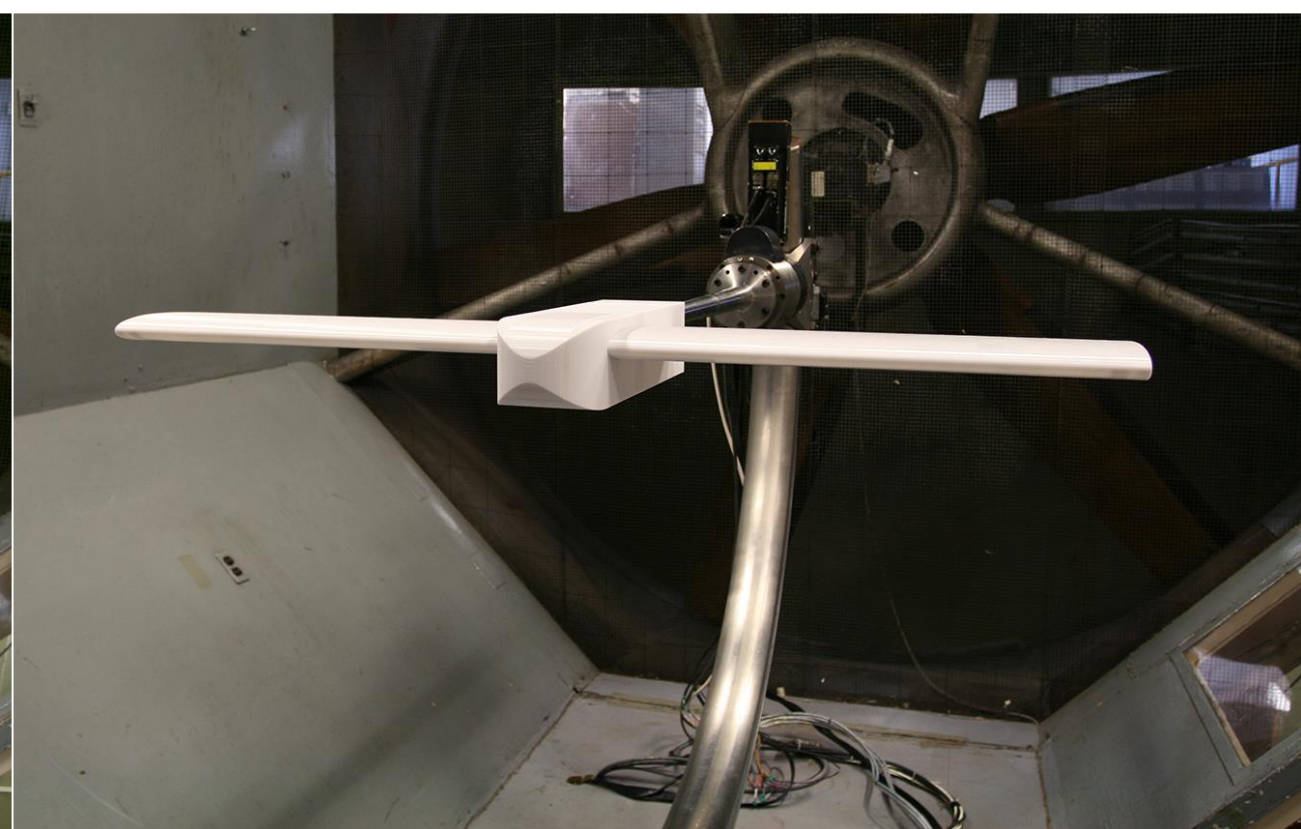
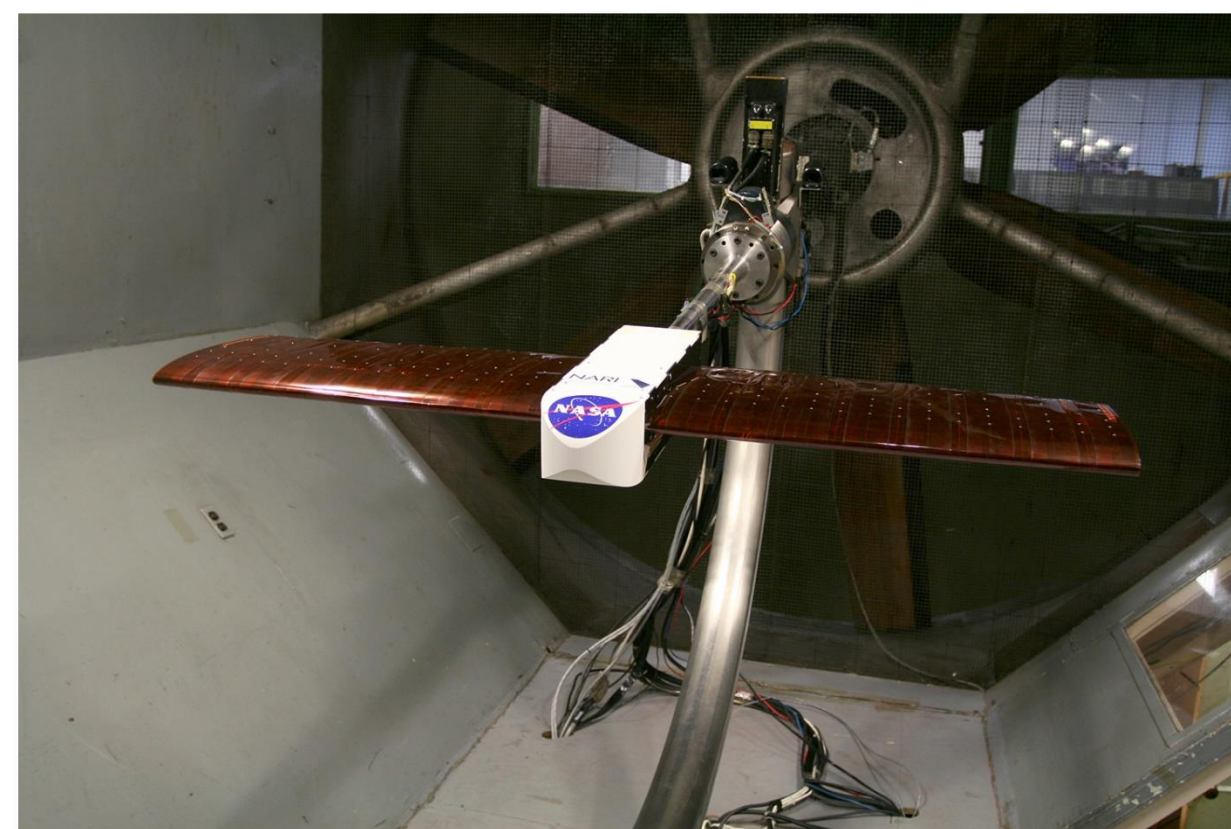
**Rigid flaps**  
Separate parts

0,  $\pm 10^\circ$ ,  $\pm 20^\circ$ ,  
 $\pm 30^\circ$  both sides





# Rigid and Flexible Models Mounted



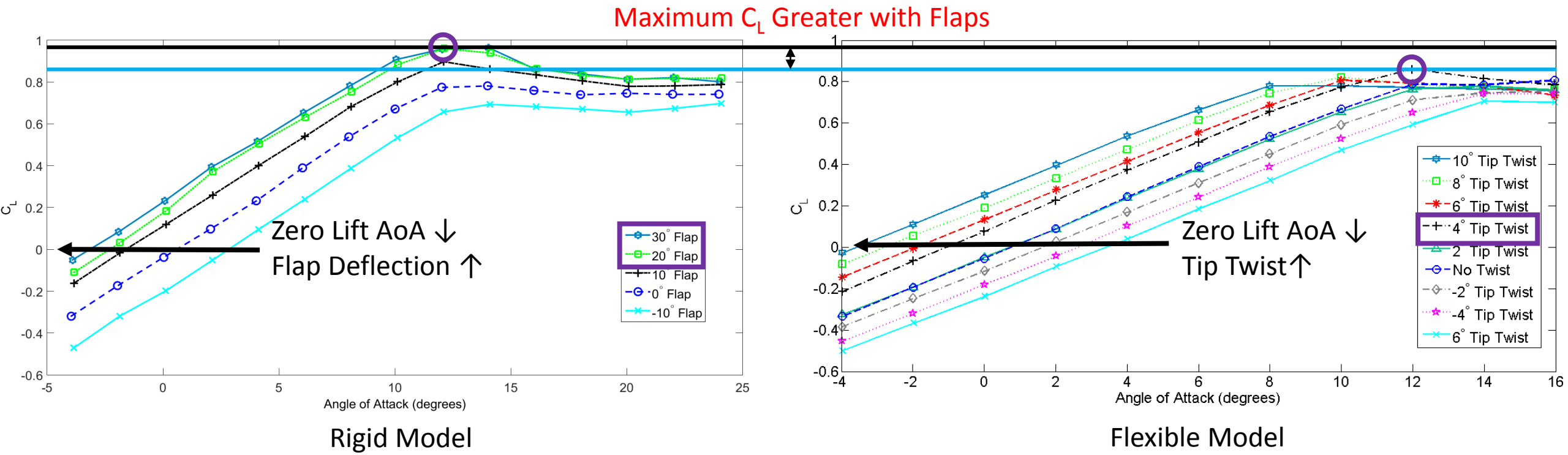
# Alpha Sweep Testing





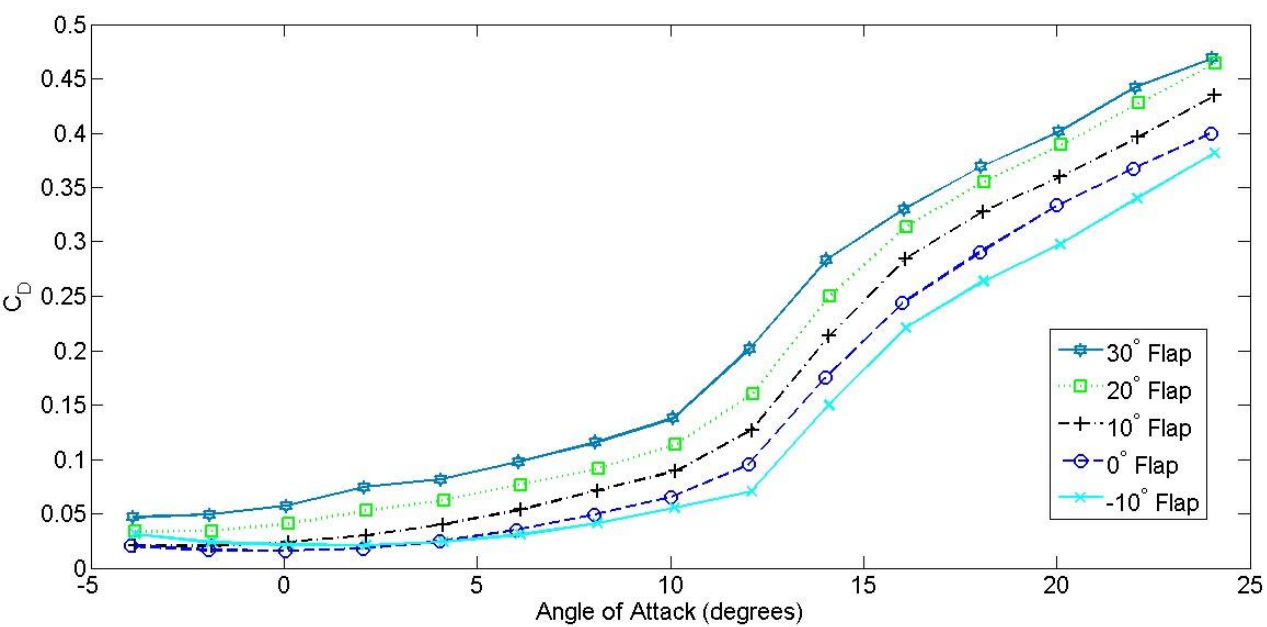
# Symmetric Results

# Comparison of Lift Curves

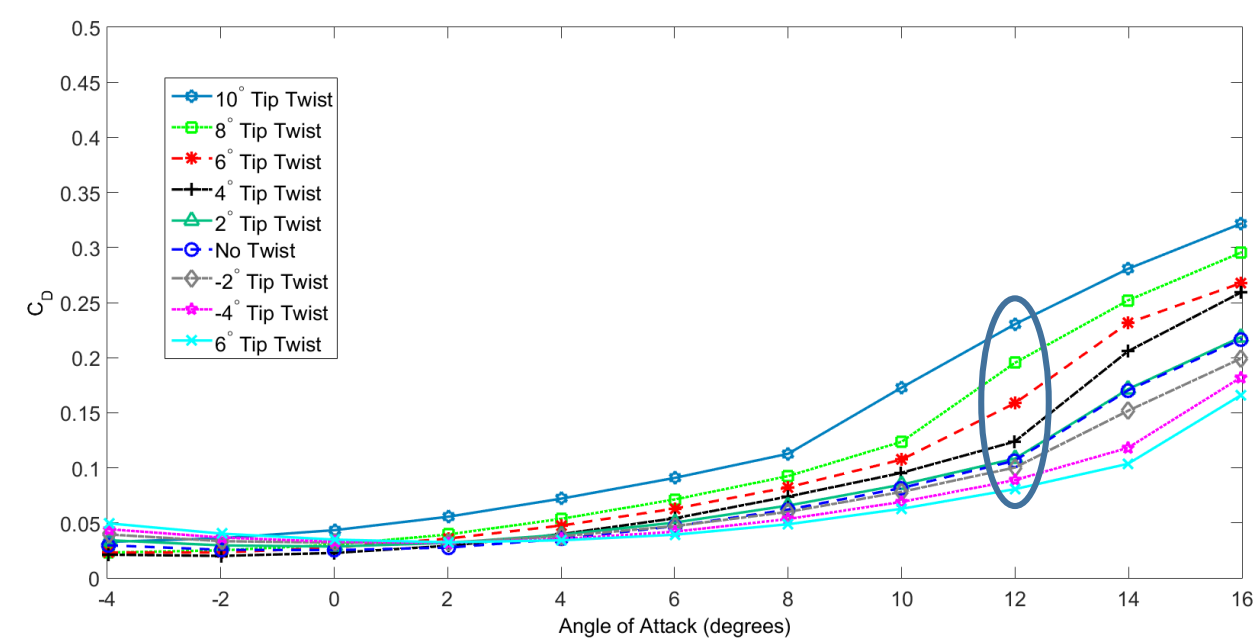


Maximum  $C_L$  at 4° Twist and 20/30° Flaps

# Comparison of Drag Curves



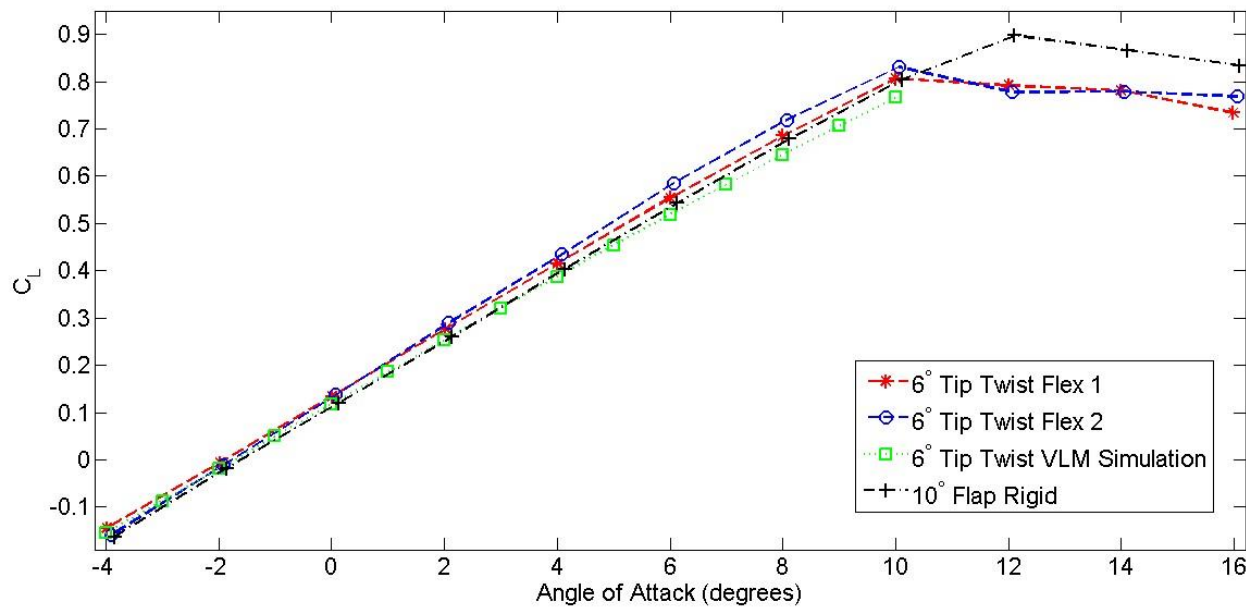
Rigid Model



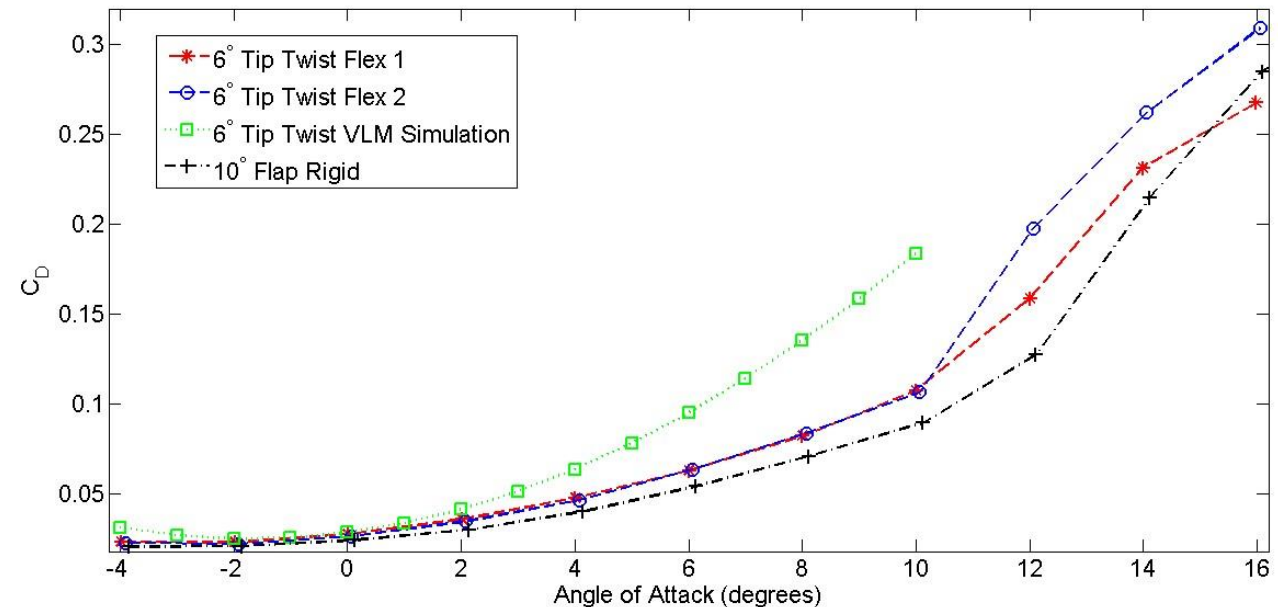
Flexible Model

4° Tip Twist had a higher  $C_L$  but lower  $C_D$

# 6° Tip Twist and 10° Flap Comparison



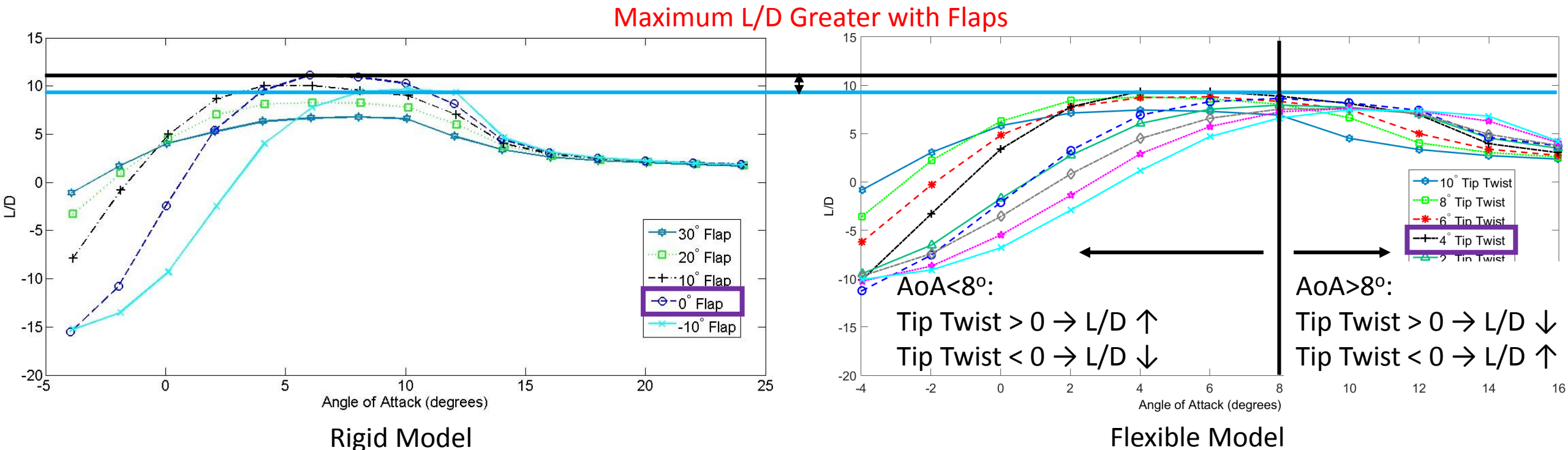
Rigid Model



Flexible Model

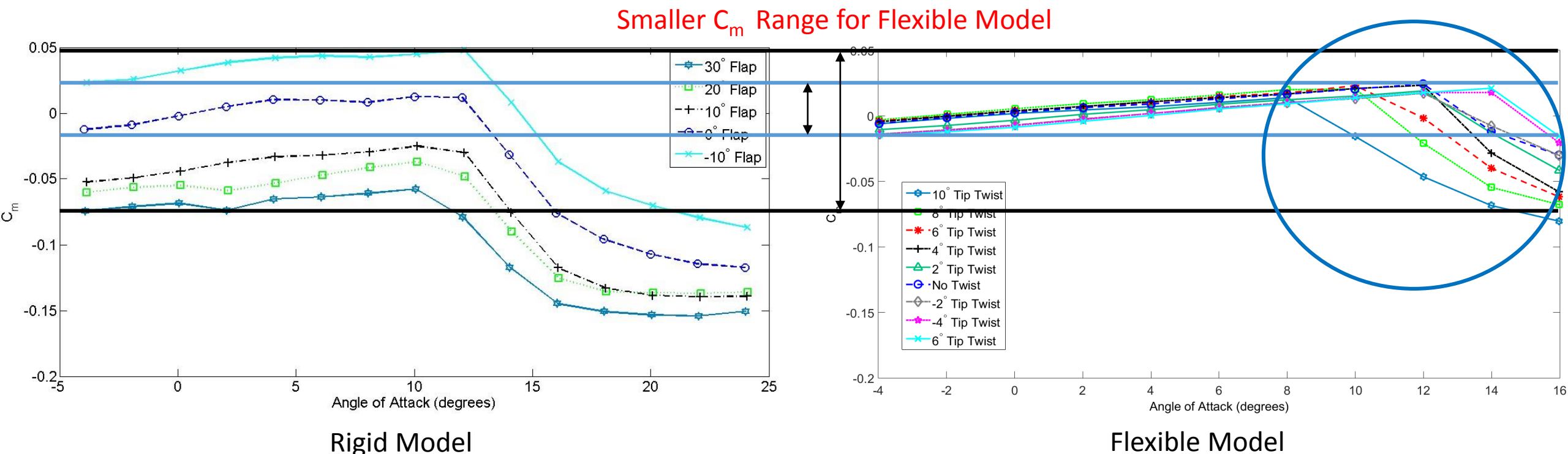


# Comparison of Lift/Drag Curves



Maximum L/D at 4° Twist and 0° Flaps

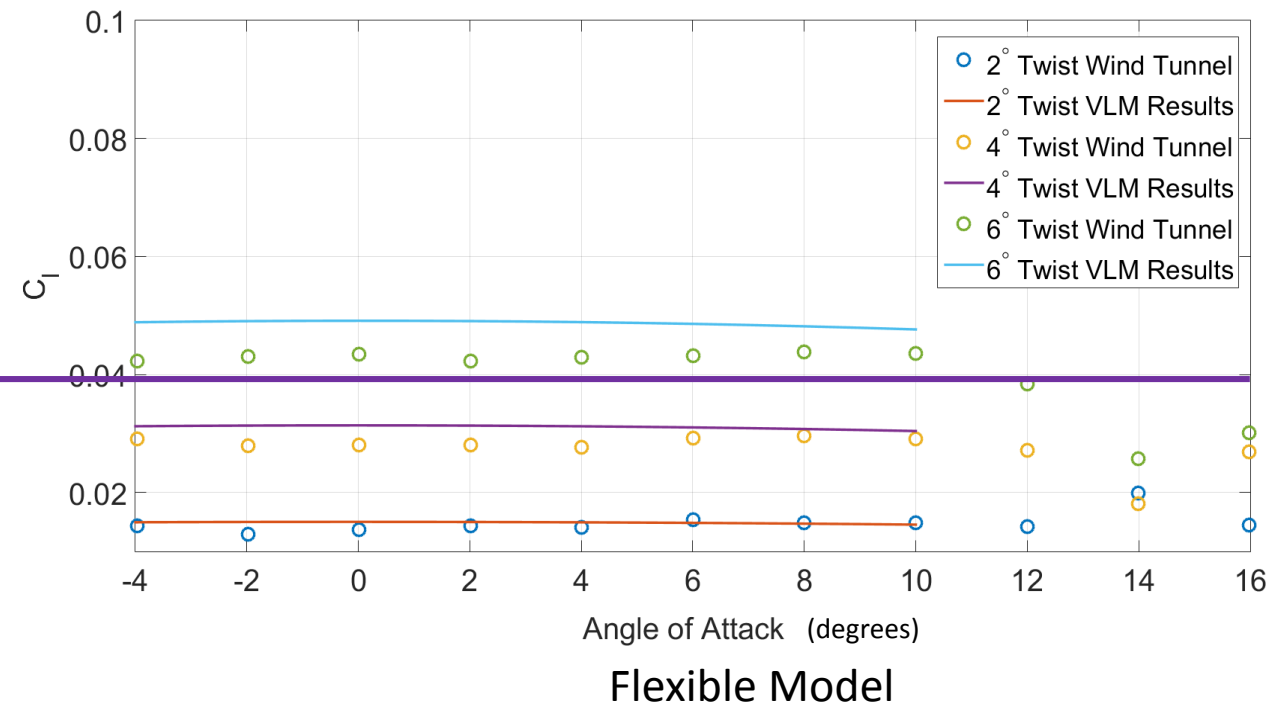
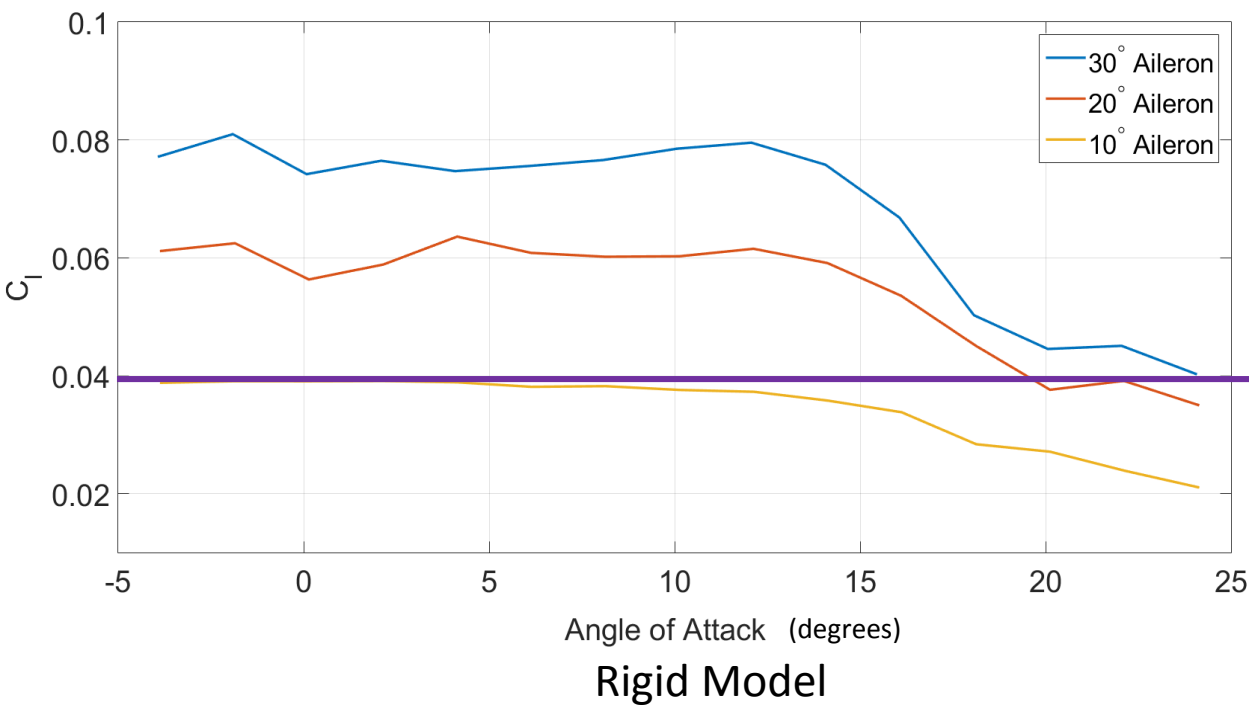
# Comparison of Pitching Curves



Pitch Stable Region can be Controlled by Twist

# Asymmetric Results

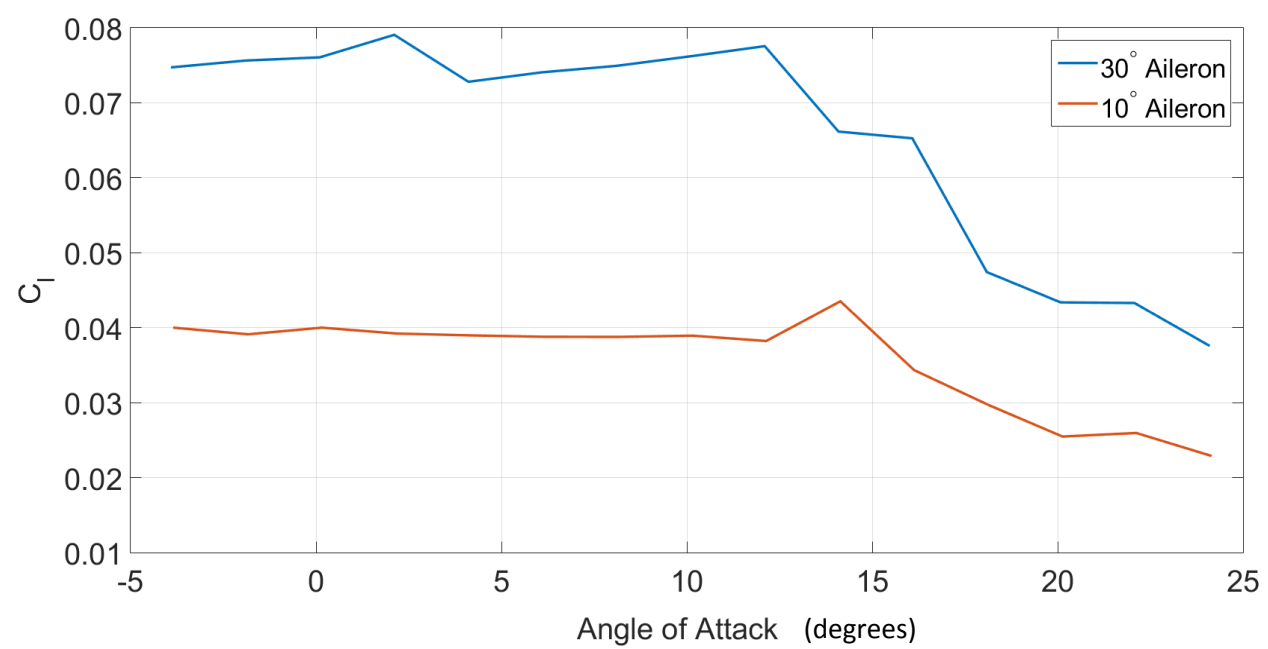
# Comparison of Roll Curves



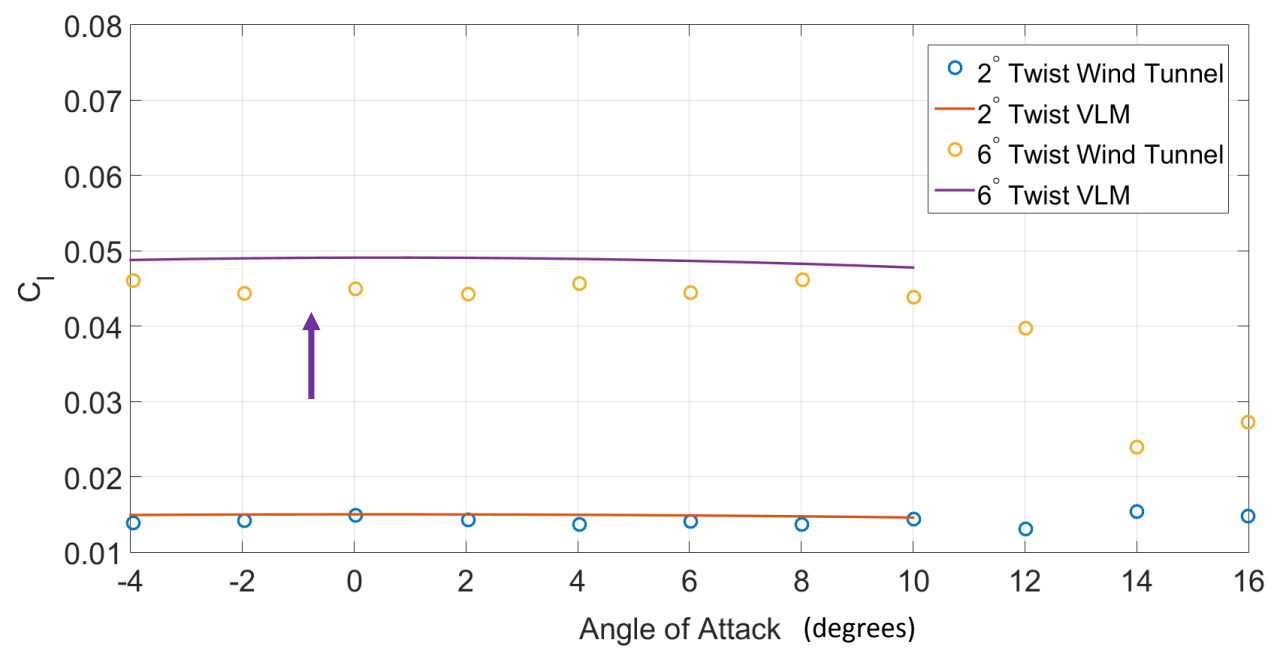
6° Tip Twist still Comparable to 10° Flaperon



# Comparison of Roll Curves across Q



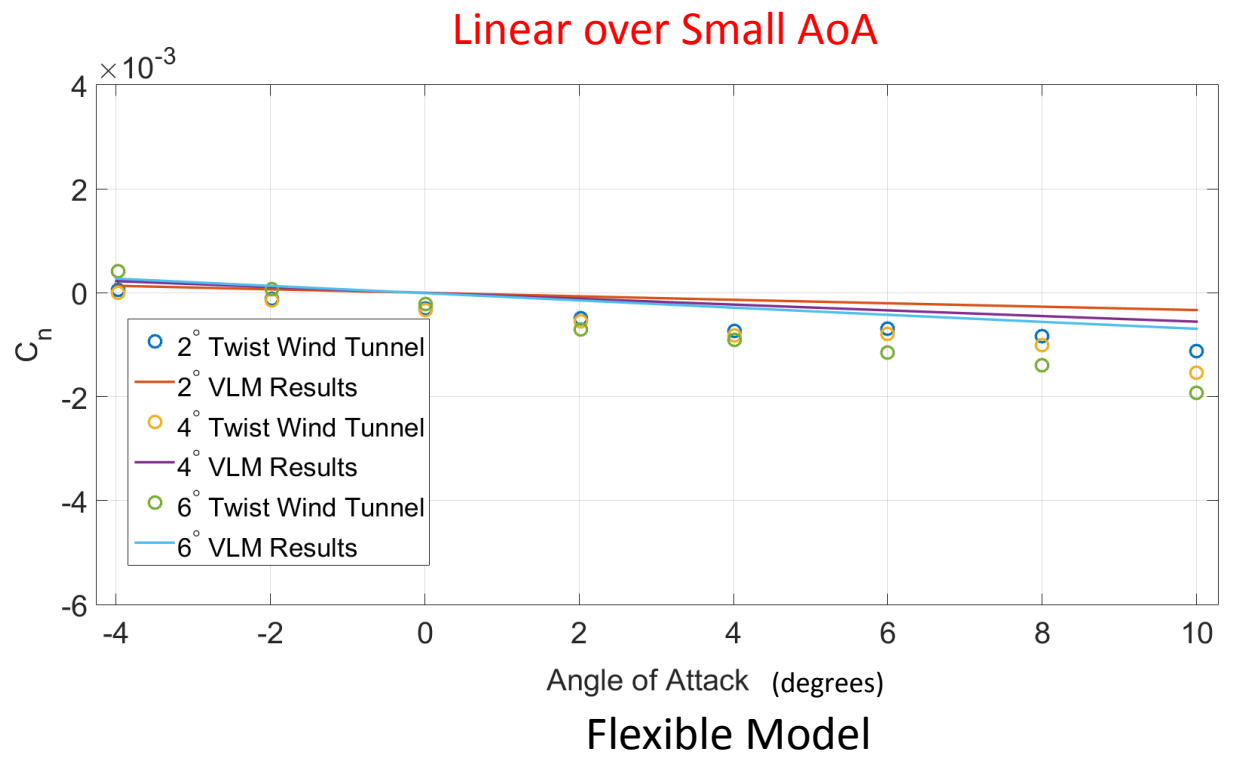
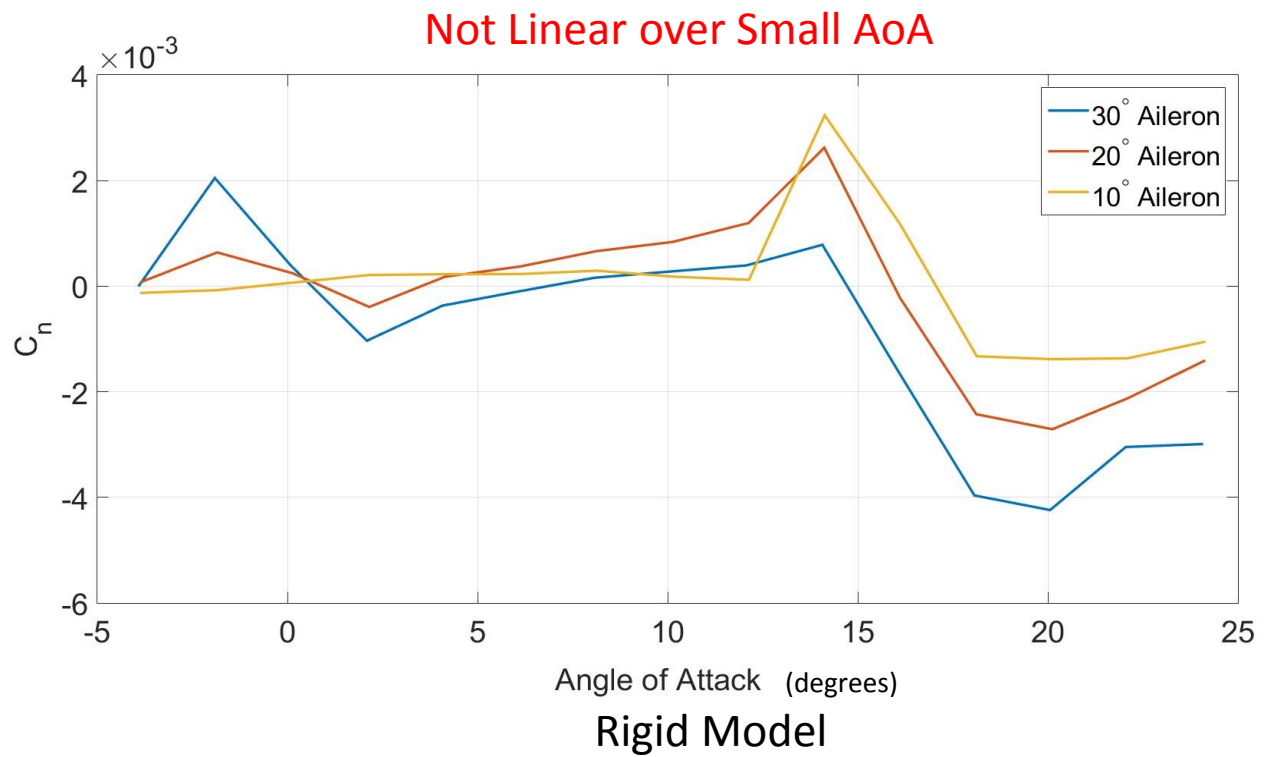
Rigid Model



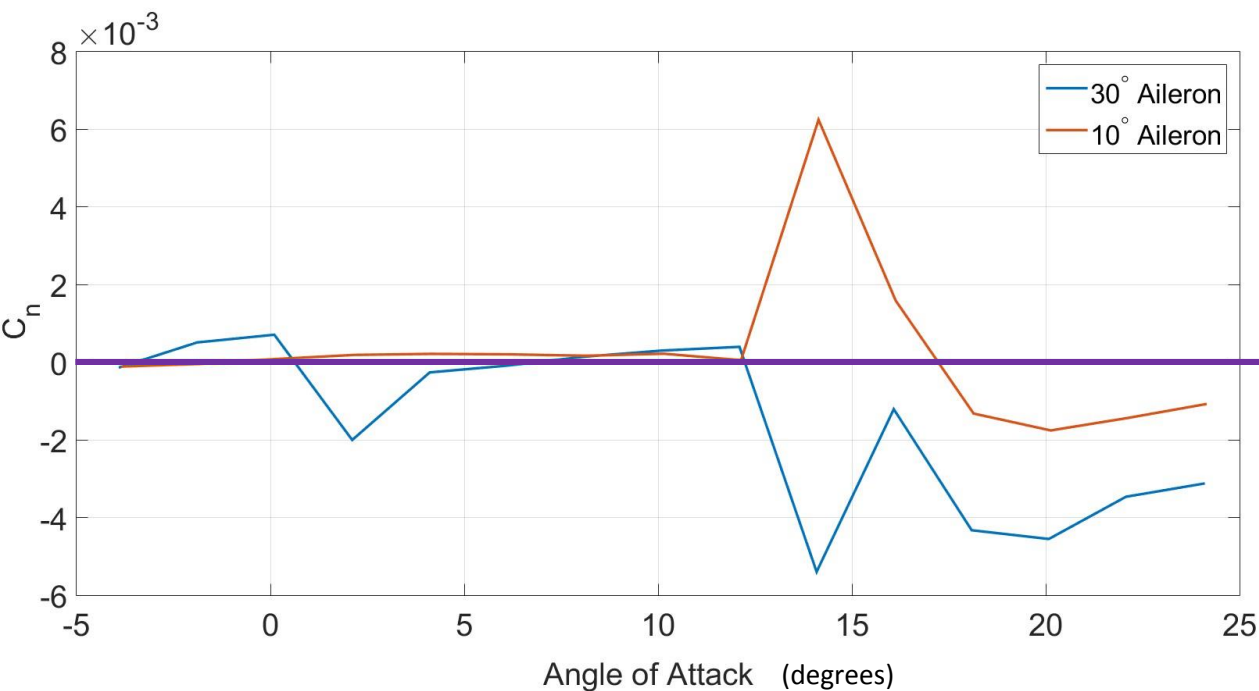
Flexible Model

Roll Increases and Approaches Theory

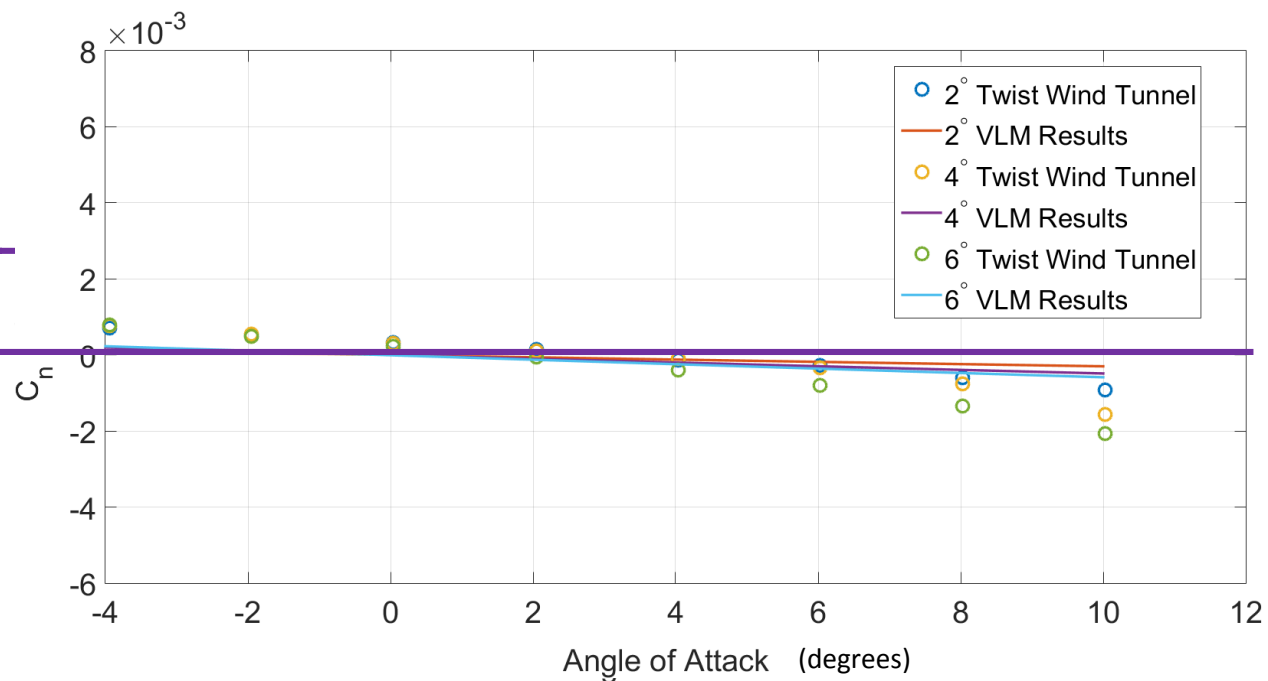
# Comparison of Yaw Curves



# Comparison of Yaw Curves across Q



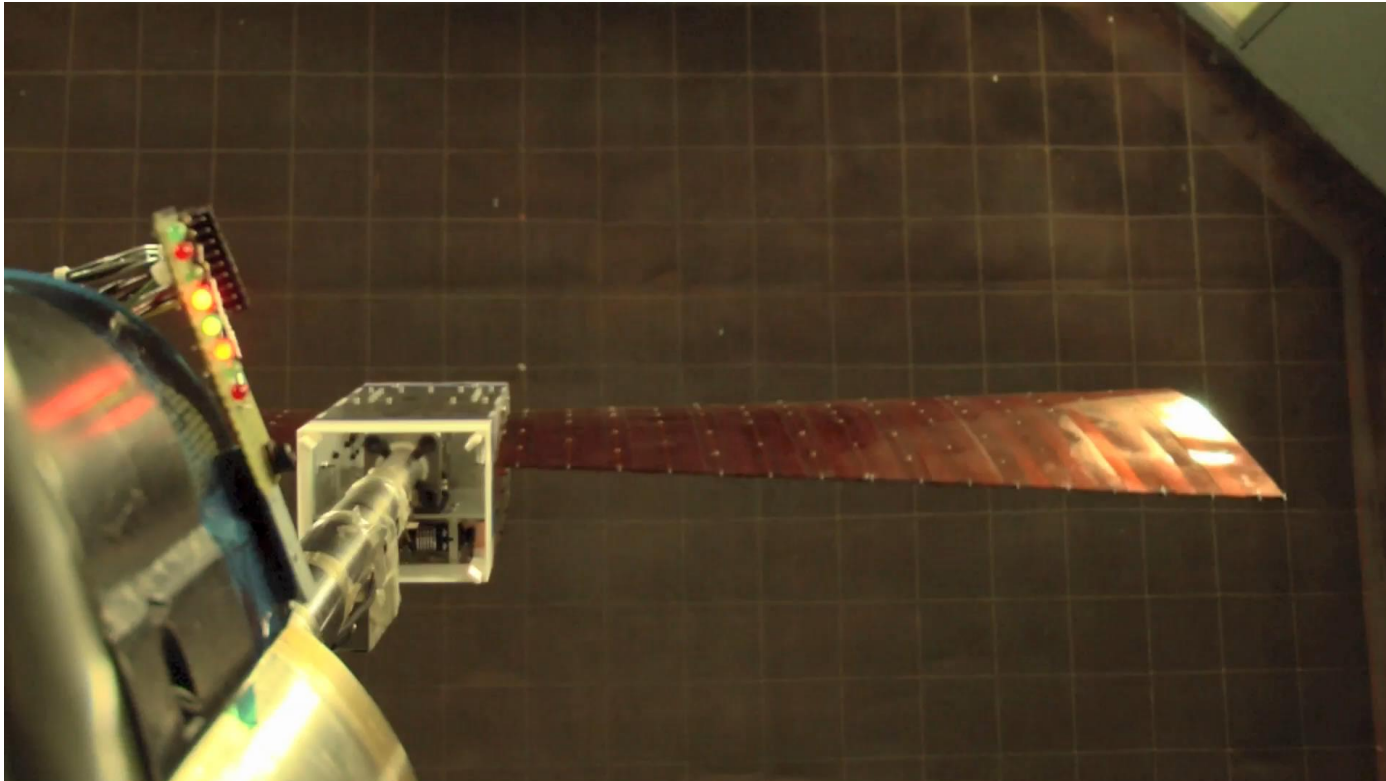
Rigid Model



Flexible Model

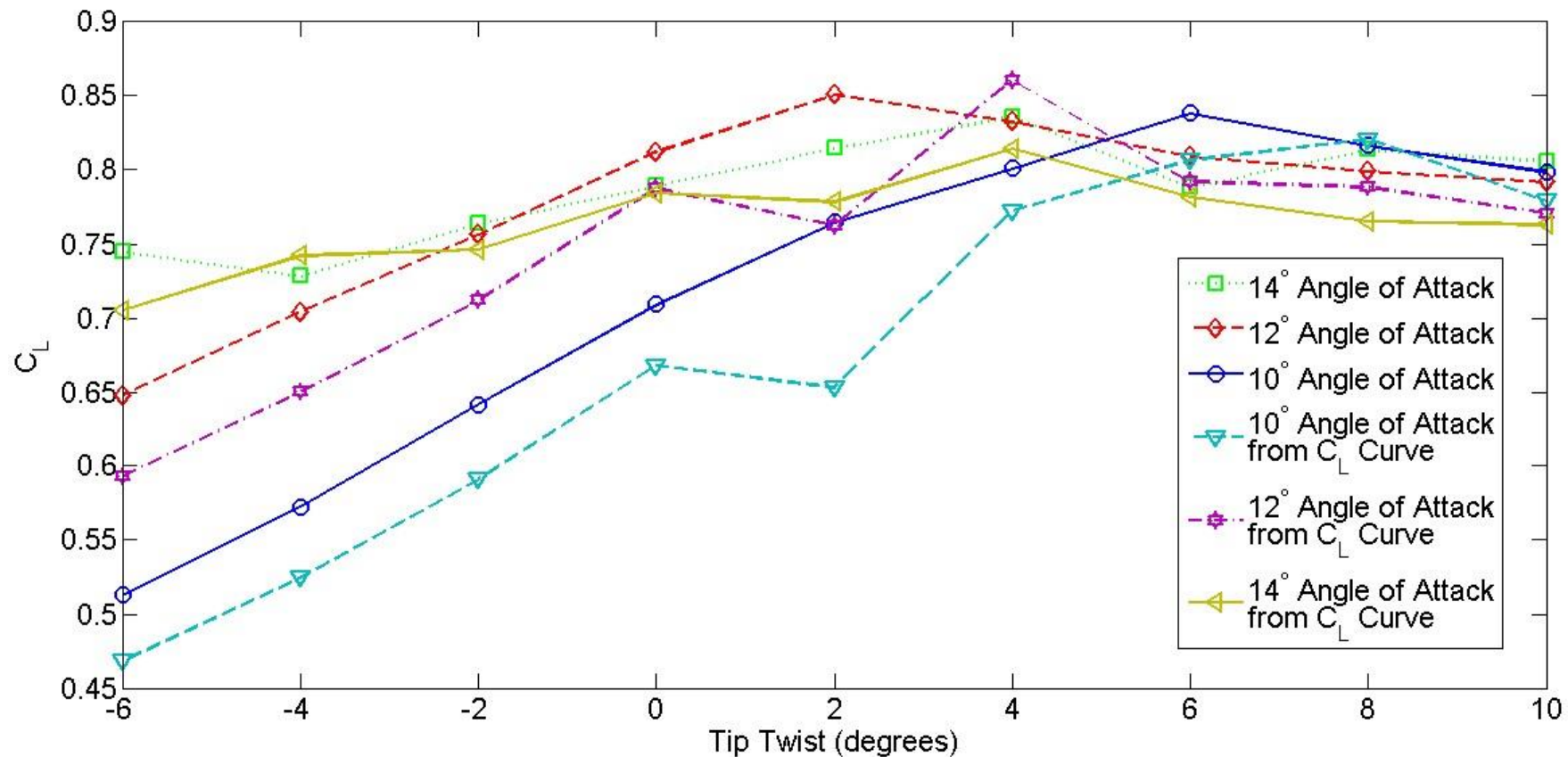
Zero Yaw Point Changes with Q

# Stall Mitigation





# Stall Mitigation Comparison



# Special Thanks to the LaRC 12-ft Test Team



# Acknowledgements

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